Cardiopulmonary Bypass in Cyanotic Patients

A Review of the Problems and Suggested Strategies
Cardiopulmonary Bypass in Cyanotic Patients

Extra-ordinary Problems Encountered During C.P.B. for Cyanotic Heart Disease

1. Extra Dilutional Requirements
2. Predisposition to Post-operative Bleeding
3. Numbers of Collateral Vessels
4. Re-oxygenation Injury
5. Others
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1. Dilution

- ↓ Viscosity
- ↑ Shear rates
- ↑ Perfusion
- ↓ Blood requirements in priming
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1. Dilution

Generally: 20 - 40% or 20 - 40ml/kg.

Cyanotic patients require greater dilution in order to:

↓ viscosity
↑ shear rates
↑ perfusion
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1. Dilution

in cyanotic patients .....

↓ Oxygen Carrying Capacity
↓ Leucocyte & Platelet Numbers
↓ Coagulation Proteins
↓ Plasma Oncotic Pressure
↑ Diuresis
Cardiopulmonary Bypass in Cyanotic Patients

Turner-Gomes S.O., Williams W.G., et al


- Thrombin Regulation & Activity
- Cyanotic Patients
  - Higher Risk of Haemorrhage
  - Dilutional in Origin
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Milam, J.D., Cooley, D.A., et al

J. Thor. C.V. Surg. 89 (4), 1985

111 Patients

Group 1: Non-cyanotic Normal Dilution Hb<10
Group 2: Cyanotic Normal Dilution Hb>10
Group 3: Cyanotic Dilution To Below 10gm% Hb<10

R.C.H. 98
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MILAM et al. - Results

- At 24 Hrs Grp3 Hct > Grp 1 (↑ Diuresis)
- Grp 3 Platelets Only ↓ To 106,000
- Grp 3 Fibrinogen, Factors X, IX, VII, V, Ii All ↓ And
- Grp 3 APTT & PT Prolonged
  But
- Grp 3 Bld. Loss 45% Less Than Grp 2
  And
- Grp 3 Bld. & Bld. Product Usage 54% Less Than Grp 2
- Grp 3 Re-op (Bleeding) 14%
- Grp 2 Re-op (Bleeding) 40%
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MILAM et al. - Findings

- Haemodilution Is A “Must”
- Suggests Albumin Or F.F.P.
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2. Post-Operative Bleeding

In Cyanotic Patients......

- ↑ erythrocyte number
  ↓ plasma volume & ↓ clotting factors
  leucocytes, platelets

- hepatic congestion
  (secondary to c.h.d.)
  ↓ production of clotting factors
2. Post-Operative Bleeding
In Cyanotic Patients......

- ↓ Clot Retraction
  - ? Hypo-fibrinogenaemia
- ↓ Platelet Aggregation
  - Inverse Relationship
  - ? Cause

- Implicated In Low Grade D.I.C.
2. Post-Operative Bleeding in Cyanotic Patients


- Found

Cyanotic Patients - Baseline GP Ib Receptor Deficit
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2. Post Operative Bleeding

Whilst On C.P.B. ....

- ↑ Dilution of platelets, clotting factors
- ↑ Cardiotomy suction
  - Platelet damage/dysfunction
  - Thromboxane & ADP release
- C.P.B. Itself
  - Platelet dysfunction
  - Protein damage
2. Post Operative Bleeding


- Preoperative transexamic acid

Significant reduction in post-op blood loss and blood product requirements.
3. Increased Collateral Return

Cyanosis Often Means....

- ↑ Blood in I.A.

→ ↓ Systemic flow

? ↑ pump output

→ ↓ Visibility in operative field

? ↓ pump output
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3. Increased Collateral Flow

- ↑ Cross-clamp times
- ↑ Cardiotomy suction
- ↑ Rewarming of myocardium
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4. Re-oxygenation Injury

Buckberg Group

- J. Clin. Invest. 93(6), 1994

- Rapid ↑ in oxygenation of hypoxic tissue
  - ↑ Cytotoxics (No, OFRS, PO-NO₃)
  - Negates effects of beneficial CPS
- CPB in hypoxaemic pts. MUST be instigated using lowest pO₂
5. Cyanosis - Other Considerations


Circulation. 86(5) (Supp II), 1992

Choreoathetosis & CPB

• Found:
  Higher incidence in cyanotic patients with systemic to pulmonary collaterals
5. Cyanosis - Other Considerations


Cyanotic dog model
- Found:
  - global ventricular function
  - ATP stores

- Suggests cyanotic patients at higher risk
- ? Special CPS needed (cf Buckberg)
5. Cyanosis - Other Considerations


J. Thor. C.V. Surg. 95(2), 1988

<table>
<thead>
<tr>
<th></th>
<th>Cyanotic Grp</th>
<th>Non-cyanotic Grp</th>
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<tbody>
<tr>
<td>Mean Age</td>
<td>6.3 yrs</td>
<td>54 yrs</td>
</tr>
<tr>
<td>Haemoglobin</td>
<td>15.5 gm/dl</td>
<td>11.0 gm/dl</td>
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<tr>
<td>X-Clamp Time</td>
<td>41 min</td>
<td>70 min</td>
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<tr>
<td>Pre-Clamp ATP</td>
<td>24 mmol/kg dry wt.</td>
<td>16 mmol/kg dry wt</td>
</tr>
<tr>
<td>Myocardial Temp</td>
<td>12.5 deg C</td>
<td>16.9 deg C</td>
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</tbody>
</table>
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del Nido et al. - Results

- After Similar Myocardial Protection
  
  ↓ ATP Levels
  ↑ Lactate levels

- Histopathology In Cyanotic Group
  
  Focal myocyte necrosis
  Presence of contraction bands
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del Nido et al.

Suggests:

- Cyanotic patients are more susceptible to ischaemic insult and to reperfusion injury

- May have a defect in oxidative metabolism

- ? Improved cps needed (cf Buckberg)
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Summary

- Dilute adequately
- Maintain protein levels on C.P.B
- Cooling
- Prepare for post-operative bleeding
- Introduce CPB appropriately
- ? Research into appropriate protocols for cyanotic patients

R.C.H. 98
Antioxidant supplementation of the CPB prime avoids unintended reoxygenation injury and results in improved biochemical and functional status.

Ihnken K. Buckberg GD. et al
Cardiovascular Surgery. 5(6):608-19, 1997